BEES Magazine

August 2020

K S R Institute for Engineering and Technology

Department of Electrical and Electronics Engineering

BEES Magazine

Together We Make Difference

August 2020

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DIGITAL IMAGE PROCESSING IN MEDICAL IMAGES

Nandhakumar J *Vijay E*

Introduction

Digital image processing allows one to enhance image features of interest while attenuating details irreverent to a given application, and then extract useful information about the scene from the enhanced image. An image may be defined as a two-dimensional function, f(x, y), where important events of image processing in medical diagnosis. Computerized axial tomography is a process in which a ring of detectors encircles a patient and an X-Ray source, concentric with detector ring, rotates about the patient. The X-
x and y are spatial (plane) co-ordinate, and amplitude off at any pair of co-ordinates(x, y)is called the intensity or gray level of the image at that point. When x, y and the amplitude values of f are all finite, discrete quantities, we call the image a digital image. The field of digital image processing refers to processing digital images by means of a digital computer. A digital image is composed of a finite number of elements, each of which has a particular location and values. These elements are referred to as picture elements, image elements and pixels. Pixels are the term most widely used to denote the element of digital image.

The Origins of Digital Image Processing

One of the first application of digital image was in the newspaper industry, when picture were first sent by submarine cable between London and New York. Introduction of the Bart lane cable picture transmission system in the early 1920s reduced the time required to transport a picture across the Atlantic from more than a week to less than three hours. Specialized printing equipment coded pictures for cable transmission and then reconstructed them at the receiving end. Some of the initial problems in improving the visual quality of these early digital pictures were related to the selection of printing producers and the distribution of intensity levels. In facts, digital images requires so much storages and computation power that progress in the field of digital image processing has been dependent on the development of digital computers and of supporting technologies that include data storage, display and transmission. The digital image is composed of a finite number of elements, each of which has a location and values. These elements are referred as picture element, image element &pixels. Pixels used to denote the element of a digital image. The process of acquiring an image of the area containing the text, preprocessing that image, extracting the individual characters describing the character in the form suitable for computer processing & recognizing those individual character are Digital Image Processing. Digital image processing techniques began in the late 1960s and early 1970s to be used in medical imaging, remote Earth resource observations and astronomy. The invention in the early 1970s of computerized axial tomography (CAT) also called computerized tomography (CT) is one of the most

Ray passes through the object and is collected at the opposite end by the corresponding detectors in the ring. As the source rotates, this procedure is repeated. Tomography consist algorithms that use the sensed data to construct an image that represent the slice through the object. Computer procedure are used to enhance the contrast or code the intensity levels into color for easier interpretation of X- Rays and other imagesused in industry, medicine and the biological sciences. Image enhancement and restoration procedure are used to process degraded images of unrecoverable objects or experimental result too expansive to duplicate. Image processing methods have successfully restored blurred pictures that were the only available records of rare artifacts lost or damaged after being photographed.

The internal structure of the human body is not generally visible to the human eyes. However, by various imaging techniques images can be created through which the medical professionals can look into the body to diagnose abnormal conditions and guide the therapeutic procedures. Different medical imaging methods reveal different characteristicsof the human body With each method, image quality and structure visibility can be considerable, depending on characteristics of the imaging equipment, skill of the operator, and compromises with factors such as patient radiation exposure and imaging time

MEHODOLOGY

Noise Models

Real images are often degraded by some random errors This degradation is usually called noise. Noise can occur during image capture transmission or processing and may dependent on or independent of image content. Basically, there are two types of noise models: Noise in the spatial domain (described by the noise probability density function) and noise in the frequency domain described by various Fourier properties of the noise. Now here with we are discussing about the noise is independent of image co- ordinates.

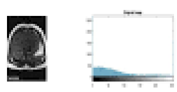
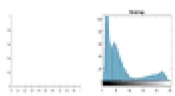
Noise	Histogram of Noisy Image	Histogram of filtered Image
Speckle Noise		

Table of MRI Single Image with their histogram

Gaussian Noise

Gaussian noise is popular noise approximation. A random variable with Gaussian (normal) distribution has its probability density is given by the Gaussian curve.

The ID case the density function is

P(x) = 1/ 2 e-(z-Âµ) 2/2 2

Where Âµ is the mean and is the standard deviation of randomvariable. Gaussian noise that occurs in many practical cases.

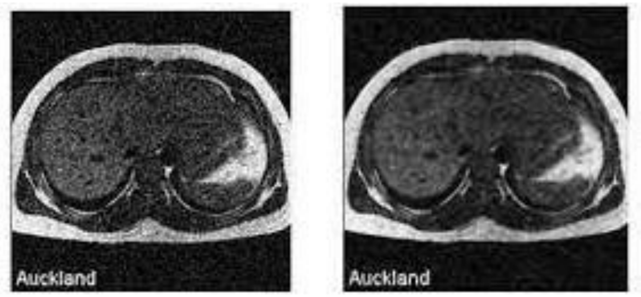


Fig6. (a)Gaussian Noise (b) De-Noised Image

Additive Noise

When an image is transmitted through some communication channel, a noise which is usually independent of the signal occurs. Similar noise arises in video camera. This signal independent degradation is called additive noise and can be described by the following models.

$F(x, y) = g(x, y) + v(x, y)$

Where $v(x, y)$ is noise, which independent of input image $g(x, y)$ and $f(x, y)$ is corrupted image. The noise magnitude depends on the signal magnitude itself

Multiplicative Noise

If the noise magnitude is much higher in comparison with the signal we can write

$F= g + gv = g (1+v) = gv$

The above equation describes the multiplicative noises is the television raster degradation which depends on TV lines in ten area of line this noise is minimal. [Gonzalez, 2005]

Quantization Noise

It occurs when in suffient Quantization levels are used for ex 50 levels for monochrome image in this case false contour appear. [Gonzalez, 2005]

Impulsive Noise

Impulsive noise means that an image is corrupted with individual noisy pixels whose brightness significantly differs from the neighborhood.

Salt and Pepper Noise

It is another type of noise is used to describe saturated impulsive noise an image corrupted with white and/ or a black pixel is an example. Salt and Pepper noise can corrupt binary image.

All the above noises can be added using the IPT function imnoise (). The basic syntax is

G = imnoise (f, type, parameters)

Where f is the input image, type is the type of noise.Function imnoise () converts the input image to class double in the range [0, 1] before adding noise to it. This must be taken account when specifying noise parameter.

G = imnoise (f, Gaussian, m, var) adds Gaussian noise of mean m and variance var to image f. Te default is zero mean noise with 0.01 variance.

G = imnoise (f, localvar, v) adds zero mean, Gaussian noise of local variance, V, to image f, where v is an array of the same size as f containing the desired variance values at each point.

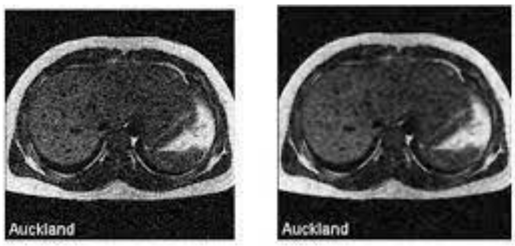


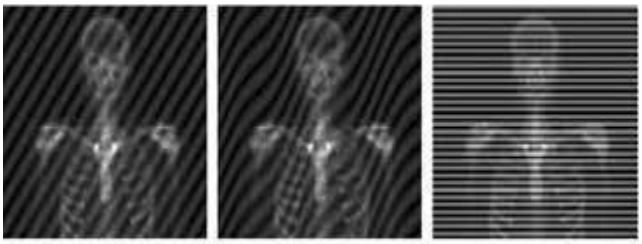
Fig10. (a) Salt pepper (b) Filtered salt pepper image

Periodic Noise

Periodic noise is an image arises typically from electrical and / or electromechanical inferences during the image acquisition. This is the only type of spatially dependent noise. Periodic noisetypically handled in an image by filtering in the frequency domain. The model of periodicnoiseis a 2-D sinusoid with equation

R(x, y) = Asin [2u0(x+Bx)/ 2v0(y+by)/N]

Where A is the amplitude, u0 and v0 determines the sinusoidal frequencies with respect to the x and y axies respectively and Bx and By are phases displacements with respect to the origin.



(a) Global (b) Local (c) Stripping

Conclusion

It is found that the Adaptive filter works better for the gaussian noise .Similarly after finding the Gaussian noise in cancer image the various filtering techniques have been applied and it is found that the adaptivefilter works better for the noisy image. After finding the Gaussian noise in X-ray image various filtering techniques have been applied and it is found that theadaptive filter works better for the X-ray noisy image. After finding the Gaussian noise in brain image various filtering techniques have been applied and it is found that the adaptivefilter works better for the noisy image. Similarly after finding the salt and pepper noise in MRI image variousfiltering techniqueshave been applied and it is found that the adaptive filter works better for the noisy image.

After finding the salt and pepper noise in Cancer image various filtering techniques have been applied and it is found that the median filter

IOT BASED HOME AUTOMATION SYSTEM

Rmaya A *Manjupriya M*

Introduction

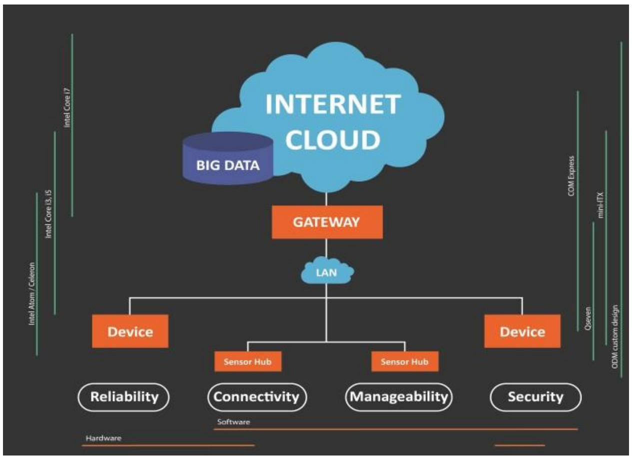
The concept of Home Automation aims to bring the control of operating your everyday home electrical appliances to the tip of your finger, thus giving user affordable lighting solutions, better energy conservation with optimum use of energy. Apart from just lighting solutions, the concept also furtherextends to have a overall control over your home security as well as build a centralized home entertainment system and much more. The Internet of Things (or commonly referred to as IoT) based Home Automation system, as the name suggests aims to control all the devices of your smart home through internet protocols or cloud-based computing.

The IoT based Home Automation system offer a lot of flexibility over the wired systems s it comes with various advantages like ease-of- use, ease-of-installation, avoid complexity of running through wires or loose electrical connections, easy fault detection and triggering and above and all it even offers easy mobility.

Basic Setup

Thus, IoT based Home Automation system consist of a servers and sensors. These servers are remote servers located on Internet which help you to manage and process the data without the need of personalized computers. The internet based servers can be configured to control and monitor multiple sensors installed at the desired location.

Let us understand in detail the working of different smart devices which together constitute the Home Automation system.

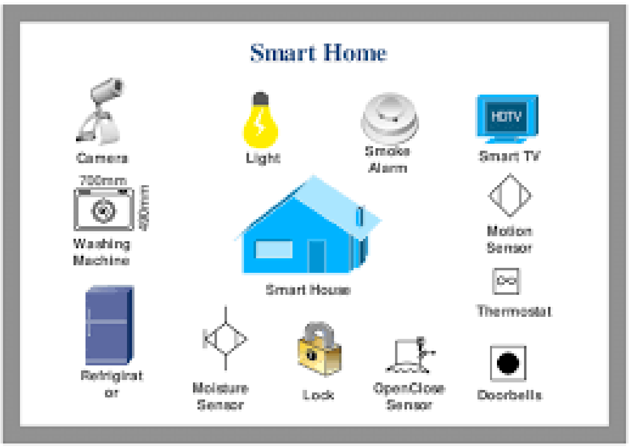


Controller

The main controller or the hub is the most essential part of your Home Automation system irrespective of whether you connect single or multiple sensors in your home. The main controller or the hub is also referred to as gateway and is connected to your home router through the Ethernet cable. All the IoT based sensors transmit or receive commands through the centralised hub. The hub in turn receivesthe input or communicates the output to cloud network located over the internet.

Due to this kind of architecture, it is possible to communicate with the centralized hub even from remote and distant locations through your smartphone. All you need is just a reliable internet connection at the hub location and the data package to your smartphone that helps you connect to the cloud network. Most of the smart home controllers available in the market from several manufacturers cater to all three widely used protocols of wireless communication for Home Automation: ZigBee, Z-Wave and Wi-Fi. **Smart Devices**

The IoT based home automation consist of several smart devices for different applications of lighting, security, home entertainment etc. All these devices are integrated over a common network established by gateway and connected in a mesh network. This means that it gives users the flexibility to operate one sensor based followed by the action of the other. For e.g. you can schedule to trigger the living room lights as soon as the door/windows sensor of your main door triggers after 7pm in the evening.



Thus all the sensors within a common network can perform cross-talk via the main controller unit. As shown in the figure, some of the smart sensors in home automation acts as sensor hubs. These are basically the signal repeaters of signal bouncers which that are located in the midway between the hub installation location and the sensors that are at a distant location. For such long distances, these sensor hubs play an important role to allow easy transmission of signals to sensors that are far away from the main controller but in closer proximity to the sensor hub. The commonly used sensor hubs in IoT based Home Automation system are Smart Plugs.

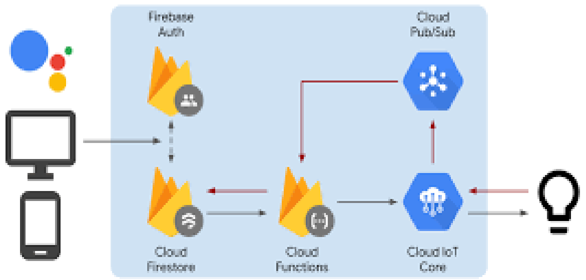
Wireless Connectivity

Most of the IoT based Home Automation systems available today work on three widely used wireless communication protocols : Wi-Fi, ZigBee and Z-Wave

The ZigBee and the Z-Wave controllers are assigned a network ID which is distributed over other sensors in the network. The communication amongst devices take place in a mesh topology where there is no fixed path for the signals transmitted from the controller to the sensors and vice versa. Depending on the availability of the shortest path the signal from the controller will travel to the target sensors either directly or through signal hops. If any intermediate sensor in the pathway is busy or occupied the signal will trace another path within the mesh network to reach the final destination. Note that sensors with different Network IDs cannot communicate with each other over common channel.

Connected with the Cloud

The Cloud-based-Networking system involves storage and maintenance of dataover the Internet location. This gives users the flexibility to have access to the data from any location on the planet.As a result of this, in IoT based Home Automation systemsusersover the cloud network can send commands to the hub even from a distant or remote location. The hub will further send the signal for the intended sensors to trigger and perform the user-requested action. Once the action is performed, the hub will update the status of the action taken to the cloud network and in this way users can control and monitor every aspect of their smart homes.



Events and Notifications

Get Notified Instantly Real-time monitoring and notifications is one of the key features of IoT based Home Automation systems. Since the hub is connected over the cloud network through the Internet, you can schedule various events as per your routine activities or daily schedules. The cloud network can receive and store all the user inputs and transfer them to the hub as per the scheduled events.

Once the hub transfer the desired signals to the target sensor and the desired action takes places, it will quickly upload the new status over the cloud notifying user instantaneously. For e.g. the motion sensor will instantaneously notify the user wither through emails, SMS, calls or App notifications when it detects any unwanted motion or intrusion. After receiving such notification, the user can quickly turn on the IP based home security smart camera can check the status of your home even from remote location.

Conclusion

Future we can develop to control the home appliance anywhere in the house or place. Most importantly we must build the most savable cybersecurity on one access the network in the house or misuse the home appliance. we described the integration of three loosely coupled components, smart home, Iot, and cloud computing. To orchestrate and timely manage the vast data flow in an efficient and balanced way, utilizing the strengths of each component we propose a centralized real time event processing application

We describe the advantages and benefits of each standalone component and its possible complements, which may be achieved by integrating it with the other components providing new benefits raised from the whole compound system. Since these components are still at its development stage, the integration among them may change and provide a robust paradigm that generates a new generation of infrastructure and applications.

As we follow-up on the progress of each component and its corresponding impact on the integrated compound, we will constantly consider additional components to be added, resulting with new service models and applications.

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NUCLEAR BATTERY

Nandhakumaaran S *Sakthivel P*

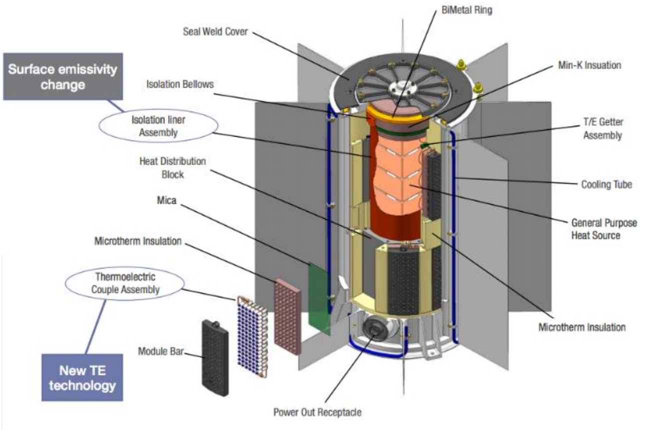
Introduction

The public is familiar with nuclear energy in nuclear power plants but not in batteries. Nuclear batteries are in fact closer to nuclear power plants than traditional batteries in that they use radioactivity to generate power instead of storing an amount of charge. When compared to chemical batteries, nuclear batteries are characterized by higher volumetric energy density (therefore longer battery life) and stronger endurance in harsh conditions. This report will explore the present state of nuclear battery technology and recently discovered possible breakthroughs.

Applications

Space exploration poses unique challenges that are not faced when working with electronics on Earth. It is impossible or extremely costly to access a device once it has been launched into the space. Because only a small percentage of sunlight reaches the outer perimeter of the solar system compared to the orbit of Earth, solar energy is not a practical solution to powering electronic equipments when exploring the outer planets. NASA uses a specific type of nuclear battery technology called Radioactive Thermoelectric Generator (RTG) to power their spacecrafts in missions that last over 10 years.

Implantable medical devices (IMDs) also utilize the unique characteristics of nuclear batteries. Just like in spacecrafts, batteries used to power IMDs must function reliably over a long period of time without being accessed for recharge or maintenance. Unlike in spacecrafts, however, batteries used in IMDs must be limited in size and radioactivity. Hence, a different nuclear battery technology called betavoltaic cell is used in IMDs. Although the technology was invented and widely used for patients in the 1970s, the potential risk of radiation convinced the medical industry to shift to lithium ion batteries in the 1980s. Only with the recent advancement in safety of nuclear batteries, the option with a considerable advantage in battery life is being reconsidered.



The United States Department of Defense requires that every missile and aircraft be equipped with an anti-tamper protection such that the technology cannot be reverse-engineered by others.

Because a single instance of battery malfunction can wipe the memory circuit's configuration, batteries used in anti-tamper system must withstand temperatures between -65 and +150 degrees Celsius, high-frequency vibrations, and high humidity. [1] Lockheed Martin Missiles and Fire Control, therefore, uses nuclear batteries to power the anti-tamper system under harsh conditions and prolonged usage. [1]

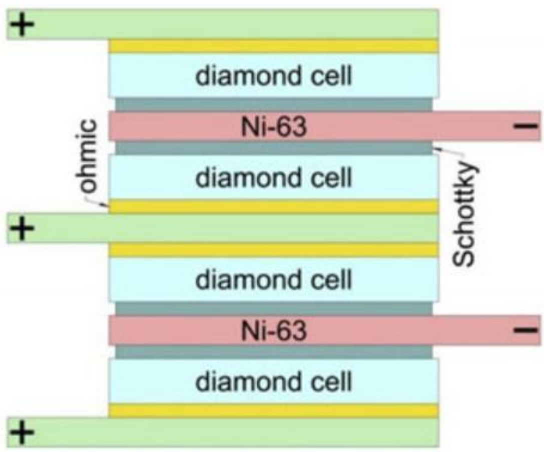
Radioactive Thermoelectric Generator (RTG)

Radioactive Thermoelectric Generator uses heat generated spontaneously from radioactive substances. The technology requires a large space to capture escaping heat inside semiconductors effectively. The shortcomings of RTG technology are its poor efficiency of 6%, its low power density, and its large size. [2]

NASA calls their technology Multi-Mission Radioisotope Thermoelectric Generator (MMRTG), and in 2016, NASA announced the next generation Enhanced Multi-Mission Radioisotope Thermoelectric Generator (eMMRTG). As Fig. 1 illustrates, eMMRTG improves the original MMRTG with a new thermoelectric technology called Thermoelectric Couple Assembly. eMMRTG's improved efficiency will also help NASA save plutonium which is in extreme shortage in the United States.

Betavoltaic Cells

Betavoltaic cells, also known as betavoltaic devices, are a nuclear battery technology used in small devices that cannot use Radioactive Thermoelectric Generators. Betavoltaic cells utilize beta-decay of isotopes such as tritium. Tritium is a byproduct of nuclear power plants, so manufacturing betavoltaic cells with tritium is an excellent way to turn nuclear wastes into useful goods. [3] The shortcoming of betavoltaic cells in, comparison to chemical batteries, is the low power output. According to Jonathane Greene, the CEO of Widetronix which manufactures betavoltaic cells, a package that is one centimeter-squared wide and two-tenths of a centimeter tall generates one microwatt of power. [1] In comparison, a smartphone using 50% CPU, Wi-Fi connection, and white display will use 1857 mW, so a nuclear battery is not suitable for consumer electronics.



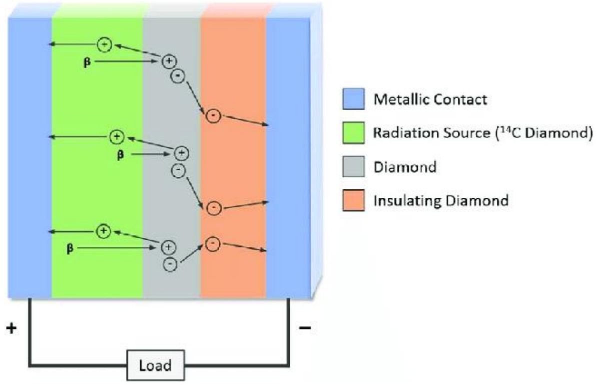
Aqueous Nuclear Battery

Baek Hyun Kim and Jae Won Kwon at University of Missouri published a paper in 2014 proposing one possible next generation nuclear battery technology. Aqueous Nuclear Battery, which is also known as water-based nuclear battery.

It uses liquid medium for radiolysis, absorbing the kinetic energy of beta particles which is lost in betavoltaic cells. In Kim and Kwon's design using nanoporous titanium dioxide semiconductors coated in platinum, a high efficiency of 53.88% was reached at a potential of 0.9 volts. [5] Using an aqueous solution for radiolytic energy conversion results in higher energy level and lower temperature than using a solid state material does.

Diamond Nuclear Battery

The University of Bristol posted a press release in 2016 introducing another possible next generation nuclear battery technology using carbon isotopes in the form of diamonds. Nuclear power generation produces radioactive waste that cannot be easily disposed. In United Kingdom alone, 95,000 tons of radioactive C-14 are deposited and decaying. Researchers at the University of Bristol discovered a way to heat and gasify the radioactive C-14 concentration on the surface of deposited nuclear graphite wastes, and condense the gas into artificial diamonds.



A man-made diamond generates an electric current when placed in a radiation field, and a diamond made of C-14 produces a radioactive field spontaneously. Hence, the diamond battery can create a constant electric current as long as it remains radioactive. Although C-14 can deliver only 15 joules per gram (compared to 700 joules per gram of standard alkaline battery), the C-14 diamond battery can generate power for 7746 years before reaching 50% charge (compared to a single day usage of standard alkaline battery). The C-14 diamond can be encapsulated in a non-radioactive diamond shell which will block all radiation and protect the battery under harsh conditions. [6] The resulting battery is made of the hardest material on Earth, so the industry might finally overcome the psychological resistance of sensitive clients such as patients using IMDs.

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UNDERWATER WELDING

Arunkumar P *Naveen S*

Introduction

Underwater welding is used in the repair of offshore structures and pipelines, ships, submarines, and nuclear reactors. Current techniques that are generally used are wet underwater welding and hyperbaric welding

The main categories of underwater welding techniques are:

Wet underwater welding

Dry underwater welding (also called Hyperbaric welding).

Wet underwater welding

shielded metal arc welding is commonly used, employing a waterproof electrode. Other processes that are used include flux-cored arc welding and friction welding. In each of these cases, the welding power supply is connected to the welding equipment through cables and hoses. The process is generally limited to low carbon equivalent steels, especially at greater depths, because of hydrogen-caused cracking.

Dry underwater welding

The weld is performed at the prevailing pressure in a chamber filled with a gas mixture sealed around the structure being welded. For this process, gas tungsten arc welding is often used, and the resulting welds are generally of high integrity.

The applications of underwater welding are diverse – it is often used to repair and construct ships, offshore platforms, and pipelines. Steel is the most common material welded.In terms of underwater cutting, oxygen-arc cutting with exothermic electrodes and steel tubular electrodes are also used. Due to the danger and demands on the body, welders or cutters often work 1 month on and 3 months off.

Deep Underwater Welding

The definition of underwater welding usually refers to the wet welding technique where there is no mechanical barrier that separates the welding arc form the water. For deep water welds and other applications where high strength is necessary, dry water welding is most commonly used. Research into using dry water welding at depths of up to 1000 m are ongoing.

In general, assuring the integrity of underwater welds can be difficult, especially wet underwater welds, because defects are difficult to detect. For the structures being welded by wet underwater welding, inspection following welding may be more difficult than for welds deposited in air.

Process

- Use a pre-job meeting to do a job safety analysis. Get the crew together at the beginning of the job to review the hazards and plan. (Use the Job Safety Analysis – JSA format)

- Use an adequate size DC welding generator using straight polarity. Straight polarity is obtained by connecting the negative lug to the torch and the positive to the ground lead. Never use AC for burning or welding in the water. The electrical shock caused by AC current prevents voluntary relaxation of the muscles that control the hands. If electrocuted a diver may be unable to let go if his body or equipment accidentally enters the electrical circuit. If you use a rectifier machine, use a modern one that has up to date technology
- Divers should wear insulated gloves at all times when burning or welding.
- Attach the ground lead of the generator as close to the worksite as practical so that the diver is never between the electrode and the ground.
- Make sure there is a positive operating disconnect switch on the torch side of the current. When the diver is changing burning rods or doing anything other than burning, the disconnect switch must be in the open position (as shown). It is important that the opening and closing of the switch be directed by the diver. Each command should be confirmed by the diver using the terminology "make it hot," or "make it cold."
- Polarity can be checked by immersing the rod tip and ground clamp into a bucket of saltwater 2″ apart. Energize the rod by closing the safety knife switch. A stream of the bubble should rise from the rod tip. If not reverse the polarity and retest.
- After the diver enters the water, the first task is to clean a spot for the ground clamp. The spot should be in a position in front of the diver, as close as practical to the weld joint and should be scraped or wire brushed shiny clean. For diver safety, only C-type clamps should be used as grounding clamps for underwater cutting or welding operations. The clamp must be firmly secured to the workpiece and the cable should have
- sufficient slack to prevent it from being pulled loose. The diver may elect to lightly tack weld the clamp in place when there is a possibility of it working loose. The ground should always be kept in the diver's forward line of vision.
- The diver should make a test weld to check the "heat" at working depth.
- When the electrode has been consumed to within 3″ of the torch, stop the cut and signal to "make it cold." before attempting to change electrodes. Maintain the torch in the cutting position until the tender

acknowledges “make it cold” or “switch off.”

- It is not safe to operate the welding torch without the flash arrestor in place.
- Never speed up the cutting by creating a fire or inferno deep inside the metal. Such a situation can lead to an explosion.
- Do not cut non-ferrous metals underwater since they do not oxidize and have to be melted. Cutting non-ferrous metals can result in an explosion.
- Ignition should not occur underwater when the oxygen pressure is low. This will result in the cable to burn inside itself, possible blowing holes through the cable, a situation that can result in injury.
- A diver risks electrical shock when welding or cutting when partially immersed in water.
- Acetylene is very unstable at pressures above 15 psi and is not used for underwater cutting.
- The hand should never be closer than 4″ from the electrode tip.
- The diving tender should always maintain a written record of the following in order to repeat what worked during the next welding or **cutting session:**
- The welding amperage as read from the tong meter.
- Both open and closed-circuit voltage as read from the voltmeter.
- Electrode diameter, type, manufacturer and waterproofing material.
- Electrical polarity.
- Length of welding cable.
- Depth of work site.

Welding & Burning Risks

Assuring the integrity of such underwater welds may be more difficult, and there is a risk that defects may remain undetected. The risks of underwater welding include the risk of electric shock to the welder. To prevent this, the welding equipment ought to be properly insulated, and the voltage of the welding equipment should be controlled. Underwater welders must also consider the safety issues that normal divers face; most notably, the risk of decompression sickness due to the increased pressure of inhaled breathing gases.

The Buildup of Gasses When Burning

Heat created by burning or torch can ignite trapped gases. Trapped gases need to be removed by venting or jetting gas.In closed spaces small amounts of gas can get trapped and remain with the diver. Gas must be vented if it can be trapped. Drill vent holes to allow gas to escape to the surface The surface being drilled could also have unexpected gases and should be vented, such as a pipeline. The speed of the tool can be controlled to keep temperatures at a safe level.

Make sure all pipes have been purged with an inert non-flammable gas that will not combust. Make sure that when burning is done along with salvage work that a survey of the work site identifies any overhead hazards. Make sure any pipes that can twist or tear have been addressed.

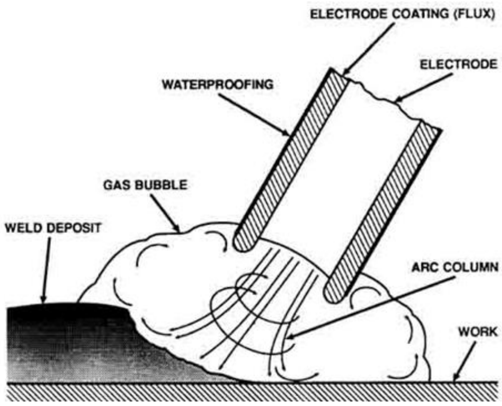
Another risk, generally limited to wet underwater welding, is the buildup of hydrogen and oxygen pockets in the weld, because these are potentially explosive. When using grinders or drills sufficient heat can ignite hydrocarbons causing an explosion. The material being burned might contain pockets that can trap burning gas. Gasses need to be properly vented. The solution is to slow down the drill bit to avoid generating the heat levels required to ignite any gas.

Mechanical Barriers And Mini-Habitats

Mechanical barriers, called Caissons and Cofferdams are used at the waters edge or in the splash zone of ships.The structures keep the water from the work area, with the weld area in the atmosphere. The technique is limited by the depth of the weld and the size of the Cofferdam. Typical uses of mechanical welding barriers are to fix a ship's hull or a harbor facility A mini-habitat is a small portable gas-filled enclosure. These are transparent plexiglass boxes that are placed over the joint by a diver. Water is then displaced by an inert gas.Both of these methods allow for dry welds, which are better than wet welds because cooling rates are slower.

Underwater Welding Arc

The welding arc does not behave underwater as it does on the surface and the activity of the gas bubble is particularly important to successful completion of the underwater weld.



When the arc is struck, the combustion of the electrode and the detachment of water creates a gas bubble or envelope As the pressure within the bubble increases, it is forced to leave the arc and meet with the surrounding water while another bubble forms to take its place.

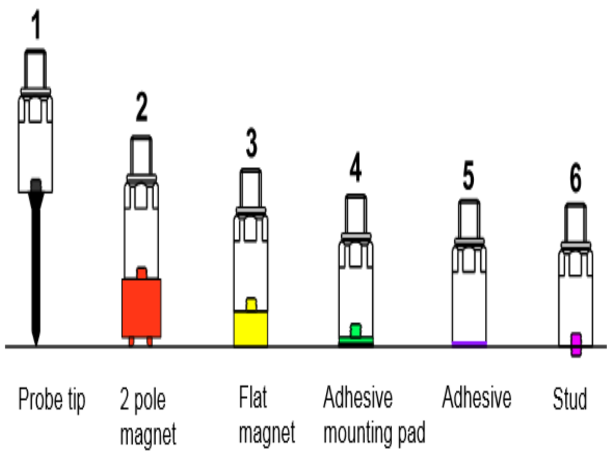
Then, as this pressure head becomes greater than the capillary force, the bubble breaks down. Therefore, if the electrode is too far from the work, the weld will be destroyed as the gases explode and blow through. If the travel speed is too slow, the bubble will collapse around the weld and destroy the possibility of producing an effective weld

SENSOR MOUNTING TECHNIQUES

Kirubakar S *Mohan T*

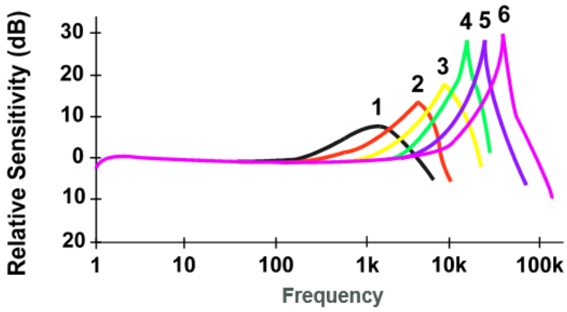
Introduction

Choosing a mounting method, and implementing it correctly, is an important factor in vibration data collection. The goal is to achieve the best possible frequency response from the mounted sensor while minimizing intrusion on the machine and working within any limitations of the application, such as guards or process requirements. There are four basic mounting methods: stud mounting, adhesives, magnets, and probe tips.



Illustrated comparison of sensor mounting methods

It's important to consider the frequency range of the application and sensor resonance. The sensor's resonant frequency is controlled by the internal preloading mass, and this frequency should be at least twice the expected application range. The frequency range of the mounted sensor will be controlled by the stiffness of the measurement technique chosen.



Relative sensitivity vs. frequency response for 6 mounting methods

Let's examine these methods in more detail and go over best implementation practices.

STUD MOUNTING

The best method for reliable data collection is threaded stud mounting, which most closely duplicates the ideal condition of sensor calibration. It allows for the widest dynamic measurement range. Stud mounting is recommended for permanent installations where high frequency (>10 kHz) vibrations are expected, and in harsh environments where handheld data collection isn't practical. Stud mounting requires drill and tapping a small hole in the machine.

When stud mounting a sensor, be sure to spot face and clean the machine surface before tapping. The hole depth should not exceed the thickness of the mounting surface to prevent damage to the machinery. Check for perpendicularity of the hole to ensure a good surface interface with the bottom of the sensor. It's also important to apply the appropriate mounting torque. For a typical 1/4-28 stud, 30 in-lbs is generally about right; certain applications can require lower or higher torques depending on severity. Using a coupling fluid such as silicon grease, machine oil or petroleum jelly will increase the mounting stiffness and enhance frequency response.

ADHESIVE MOUNTING

If the machine can't be drilled for stud mounting, adhesive mounting is generally the best alternative. Cementing pads, when used correctly, approach the high frequency characteristics of stud mounting. They work well for permanent installations where drilling is not an option and for some temporary applications, such as machine investigations.

Adhesive selection is critical for long-term reliability – some common choices are VersiLock 406, Loctite Depend or Liquid Metal, or other 'hard' glue (cyanoacrylate). Some adhesives help to electrically isolate the sensor from the mounting surface. Before applying any adhesive, all paint and debris should be removed from the surface of the machine and the surface should be ground reasonably flat. Sensor response depends on how well the surface is prepared.

MAGNETS

Magnet mounts are usually limited to temporary applications like route-based data collection. Magnets used on walkaround data collection routes won't damage the machine or the sensor. However, due to the poorer contact between sensor and machine, magnetic mounting results in a significantly reduced frequency range. The additional mass of the magnet will result in a new, lower resonant frequency and change in the frequency range. This should be considered when analyzing measurement results.

On flat surfaces or magnet pads, use flat magnets; on irregular or curved surfaces, 2-pole magnets should be used. Flat magnets provide better contact than 2-pole magnets – the former can have a mounted resonance of 5 to 10 kHz, versus 3 to 7 kHz for the latter. With any magnet mount, pay attention to your measurement results, questioning any large spikes in the spectral data.

PROBE TIPS

Handheld probe tips are used on difficult-to-reach areas, aluminum motor frames, or for rapid trial measurement points. Probe tips present the biggest challenge in data collection. They should not be used for measurements less than 10 Hz, as machine displacement makes holding the sensor in close contact with the machine difficult. Vibration data collected with probe tips is the least reliable. Spectral data is often distorted. Additionally, the length of the probe tip will affect the measurement, with longer probes introducing more inaccuracies. Frequency response is very limited compared to other methods.

Ultimately, the best choice will depend on the application, the dynamic measurement requirements, cost, and operational constraints. Remember these key points:

- **In permanent monitoring systems, use stud mounting or cementing pads.** These methods provide long-term reliability and the best frequency response of the sensor.

- **Good surface preparation** is the key to successful stud or adhesive mounting. Following best installation practices is crucial to obtaining reliable vibration data.
- Walkaround monitoring programs can maximize the effectiveness of magnetic mounts by **ensuring adequate contact between the sensor and machine** and **examining data** for any anomalies.
- Avoid using probe tips where possible and **verify your measurements.**

Four main methods are used for attaching sensors to monitoring locations in predictive maintenance. They are stud mounted, adhesive mounted, magnetically mounted and the use of probe tips, or stingers. Each method affects the high frequency response of the accelerometer. Stud mounting provides the widest frequency response and the most secure and reliable attachment. Figure 5 shows ideal surface preparation for stud mounting sensors.

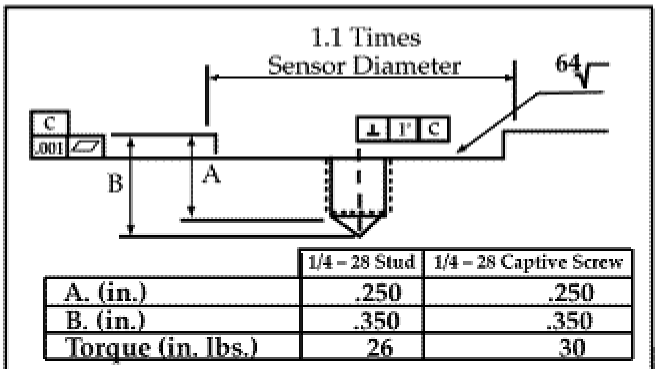


Fig. 5 – Stud Mounting Surface Preparation

When choosing a mounting method, both the advantages and disadvantages of each technique should be closely considered. Characteristics such as location, ruggedness, amplitude range, accessibility, temperature and portability may be extremely critical. However, often times the most important and overlooked consideration is the effect the mounting technique will have on the high frequency operating range of the accelerometer.

By examining the mounting configurations and corresponding graph, it can be seen that the high frequency response of the accelerometer may be compromised as mass is added to the system and/or the mounting stiffness is reduced.

The low frequency response is unaffected by the mounting technique. This roll-off behavior is typically fixed by the built-in sensor electronics. However, when operating AC coupled signal conditioners with readout devices that have an input impedance of less than 1 megohm, the low frequency range may be affected.

One last point worth noting regarding mounting involves surface preparation. In addition to surfaces being as flat as possible, clean and free of debris, and the mounting holes to be perpendicular, the mounting surfaces should be lightly coated with a lubricant. This coating aids in the transmissibility of the higher frequency vibrations and improves high frequency response of sensors. Silicone vacuum grease, heavy machine oil, or bees wax are commonly used.

OPTICAL SENSORS – INDUSTRIAL APPLICATION

Praveena M *Swathi R*

Introduction

Optical sensors are electronic components designed to detect and convert incident light rays into electrical signals. These components are useful for measuring the intensity of incident light and converting it into a form readable by an integrated measuring device, depending on the sensor type.

This article outlines the principles of operation of optical sensors, optical sensor types, considerations for optical sensor selection, and key applications.

optical sensor.

Applications of Optical Sensors

Optical sensors are ubiquitous components in electronic devices and equipment utilized in the industrial, consumer, healthcare, and automotive fields.

Medical and Healthcare

With the unprecedented need for contactless sensing due to the global pandemic, optical sensors have been utilized in sanitizer dispensers at long-term healthcare facilities to ensure health and safety compliance.

Other medical applications include biomedical devices for breath analysis and heart rate monitoring. Breath analysis can be achieved using a tunable diode laser, while the reflection of light back to the sensor through the skin can accurately monitor the human heart rate in a process known as photo plethysmography. Portable wearable sensors utilize optical sensors for both automated and manual tracking of users' health status and vital signs.

Industrial/Commercial

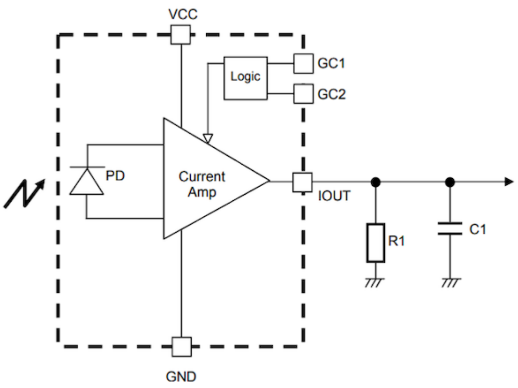
In industrial and commercial applications, optical sensors are also being used for distance and temperature sensing and automation in Industry 4.0 applications. For example, optical sensors can detect liquid levels in process engineering facilities, such as petroleum levels in tank farms and hydrocarbon refineries, by integrating an infrared LED, light transistor, and a transparent prism tip.

Optical sensors also enable automated control by detecting the presence of components on factory floors.

Consumer Electronics

Optical sensors are also being used for ambient light sensing in consumer electronics such as smartphones, with advantages such as extending battery life and optimizing screen brightness to match the amount of lighting in the environment.

The schematic below (Figure 1) integrates a microcontroller and an auto-luminous control-equipped LED driver IC to achieve an output current proportional to the amount of ambient light and mimics the spectral sensitivity of the human eye.



Ambient light sensor IC block Diagram.

Photo-interrupters and reflective-type photosensors are used for optical sensing in printers and 3D scanners for industrial and retail applications. Optical sensors are also used in surveillance equipment in commercial and residential buildings to detect intruders.

Types of Optical Sensor

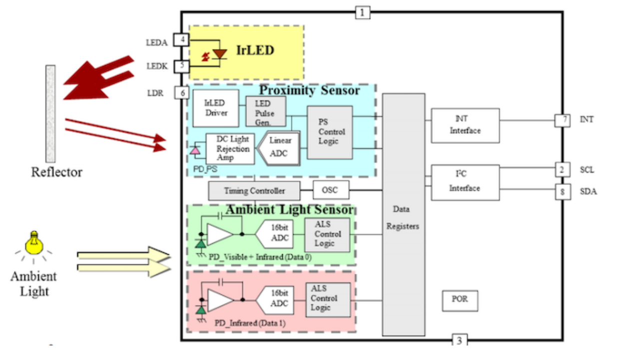
The most common types of optical sensors include:

- **Transmission-type photo-interrupters** detect the presence of objects by intercepting light and are widely utilized in applications such as position sensing and speed of rotation measurements
- **Reflective photosensors** detect the motion of objects by measuring the reflection of light across them
- **Photoconductive devices** become electrically conductive by absorbing incident light rays
- **Photodiodes** convert incident light into electric current
- **Phototransistors** achieve similar results as photodiodes when the base-collector junction is exposed to light

Operation of Optical Sensors

Optical sensing technologies require monochromatic, compact, and reliable light sources to function effectively. Common light sources suitable for optical sensor lighting include LEDs and lasers.

Light-emitting diodes (LEDs) produce light when electrons combine with holes at a junction of n- and p-doped semiconductors to aid the release of photons. On the other hand, a laser is produced by the electrical excitation of electrons in the atoms of certain materials, such as glass or crystals.



Optical proximity sensor block diagram.

Varying types of optical sensors, however, operate slightly differently.

The maximum current an output stage-based phototransistor can drive in photo-interrupters depends on the amount of light it receives. When light shines on the phototransistor (i.e., no object in the gap), photo-interrupters exhibit LOW output.

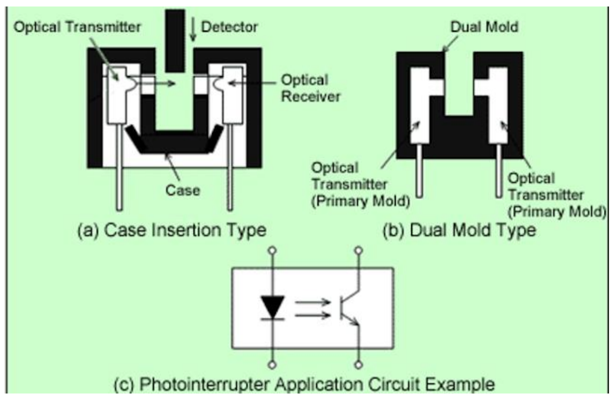


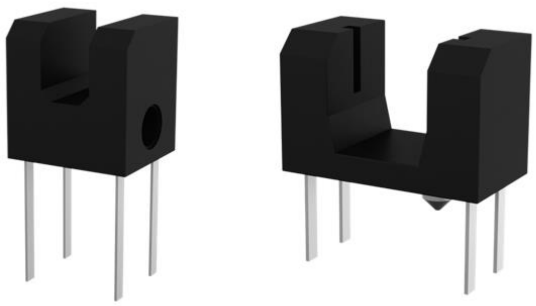
Photo interrupter construction.

Conversely, photo-interrupters exhibit HIGH output with the presence of an object. Engineers can harness the capabilities of photo interrupters by connecting the output to a microcontroller or logic device for optical control.

Design Considerations

Response times, cost, size, and sensitivity are essential considerations for engineers looking to integrate optical sensors into their designs.

Response time refers to the time it takes an optical sensor to respond to incident light and is critical in several applications. Faster response times typically result in higher optical sensing efficiencies. Many optical sensors (Figure 4) incorporate response time measurement circuits into their designs to account for their delay, rise, and fall time capabilities.



Product image of the RPI-246 (left) and the RPI-44C1E (right).

Similarly, the cost is an essential requirement for designing optical sensors. Many factors affect the overall optical sensor design cost, including hardware/software purchasing, testing, and research and development.

Sensors also come in various sizes, depending on their types and specific applications. For example, typical photo-interrupter package sizes range from 3.6 x 3.3 mm to 8 x 4.2 mm. Due to rapid miniaturization, designers will often opt for smaller optical sensors with a balance of high performance and lower costs.

Moreover, designers favor sensors sensitive to a wider spectrum of light, including visible and infrared. Higher sensitivities of up to ±40 can achieve up to four times faster proximity and ambient light sensing measurements.

Benefits of Optical Sensors

Optical sensors offer several benefits in various applications, including:

- Lightweight package
- Immunity to electromagnetic interference (EMI)
- Reliability
- Wide dynamic range
- High sensitivity

In addition, they are well suited for monitoring multiple chemical and physical phenomena and are chemically inert, which is critical in hazardous and combustible environments.

Moreover, in light of the pandemic, the need for non-contact sensing is at an all-time high. Optical sensors can be used to design innovative solutions in industrial and commercial environments to facilitate safety and health compliance.

ROHM Solutions for Optical Sensing in Electronic Applications

ROHM is a provider of high-performance optical sensor solutions. ROHM sensors offer a high degree of sensitivity, which is critical in a wide range of applications, e.g., automation, motion sensing, measurement, security, surveillance, and many more.

The optical sensing solutions include proximity and ambient light sensors, photo-interrupters, infrared LEDs, photosensors, photodiodes, phototransistors, ambient light sensor ICs, and 4-direction detectors. ROHM's optical sensors offer a wide operating temperature range (-25 to +85°C) and come in small-footprint packages for optimum space savings.

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ROTARY CONTROLS

Hemalatha S *Monisa B*

Introduction

From mechanical latches and liquid flow restrictors to the earliest radio tuners and volume adjusters, rotary controls have been a mainstay of effective interface design.

They offer precise tactile adjustment in a relatively small footprint with built-in visual feedback. High-resolution touch displays often mimic their mechanical counterparts by offering graphical rotary sliders.

UI rotary design element.

These sliders offer the same compact footprint and visual feedback as mechanical rotaries, but require an expensive display and lack the associated tactile benefits.

In most modern applications, a high-resolution color touch display is likely impractical and often even impossible. The designer must therefore resort to mechanical shafts and knobs, or attempt to achieve the same functionality with buttons or other simpler controls.

A recent example of a thin interface panel where three rotary controls are integrated with a variety of pushbuttons, indicators, and displays.

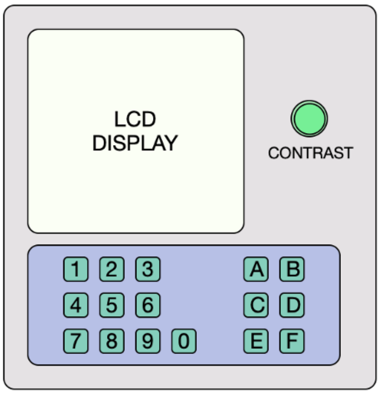
Modern thin user interface panel

Achieving an attractive and functional interface under these constraints is a difficult challenge, and requires the designer to dig deep into their tool chest and cleverly employ a wide variety of control options. This article discusses rotary control advancements and considerations for modern hardware interfaces and how relatively new technology - the MaxRotor - bridges the gaps in the current shortcomings of many potentiometers and encoders.

Designing a Hardware User Interface

For the sake of this discussion, consider an imaginary product as shown below in Figure 3, requiring an interface that includes an LCD screen with contrast control and a keypad for data entry and function selection.

The interface specifications require that it not be any thicker than 6 mm to accommodate the electromechanics mounted behind it within an industry-standard enclosure.



Imaginary product user interface.

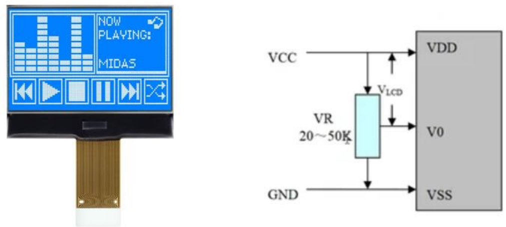
As a starting point to drive the thickness envelope, a keypad and function buttons can be implemented easily using a standard off-the-shelf or fully customized membrane solution.

As shown in Figure 4, these types of keypads are easily interfaced with common microcontrollers and are available in thicknesses of approximately 2 mm or less. A variety of panel mounting options are available including many that are tightly sealed and IP rated.

Off-the-shelf membrane keypad.

When considering the visual screen, the universe of display options has also grown in recent years to offer solutions of any shape and size ranging from e-ink and organic light-emitting diode (OLED) to thin-film transistor (TFT) and basic liquid crystal display (LCD).

An inexpensive matrix LCD display is shown as an example and includes a built-in backlight with contrast control.



LCD (left) and contrast control circuit

This type of display is also rather thin at only 2 mm and fits nicely within the constraints of the product requirement while keeping costs at a minimum.

The dedicated contrast control circuit requires delivering an analog voltage to the V0 pin within the supply range of the display circuitry. This contrast control actually turns out to be one of the more complicated challenges of the entire interface design.

Rotary Control Options

As a starting point, one might consider the venerable potentiometer shown below in Figure 6. Electrically, this could be wired simply across the power supply rails to create a voltage divider. Additionally, the center tap output could be used to drive V0 and a large value, 100 kOhms for example, would minimize power consumption and complexity.

Standard panel mount potentiometer.

Mechanically, the situation is significantly more problematic.

Challenge of Using Potentiometers

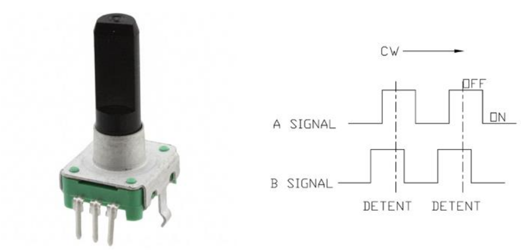
Potentiometers suffer from failure of the wipers and circuit components, typically only lasting 25-50k rotations. In addition, the knob must be secured to the panel with a nut and lock washer, and a detent must be integrated to prevent the entire structure from rotating out of alignment.

What's worse is that the body depth of most potentiometers greatly exceeds the available space, with many in the range of 9–10 mm. These characteristics in aggregate can make the potentiometer a relatively undesirable option.

Quadrature Encoders as a Rotary Solution

To achieve smaller body depth and simplify mounting requirements, another common rotary control worth considering is the quadrature encoder.

As shown in Figure 7, these encoders are available in both PCB and panel mount options very similar in nature to the potentiometer.



Traditional quadrature encoder and resulting signals.

Electrically, however, quadrature encoders introduce a whole new set of complications.

The output is typically two pulse trains that represent a particular amount of rotational travel and whose relative position can be used to ascertain rotational direction.

In order to use this for voltage control, as in the LCD contrast example above, an intermediate circuit must be used to convert the pulse train into an analog voltage.

Such a circuit is by no means simple and introduces an additional layer of complexity and cost.

Lastly, it is worth noting that the rotating pieces, electrical contacts, seals, and through-hole pins of a quadrature encoder are all encapsulated between the knob and the host PCB. This prevents the host PCB from sitting flush to the interface panel enclosure, a problem for capacitive touch sensors, buttons, and LED indicators.

The Benefits of MaxRotors

To bridge the gaps in the aforementioned shortcomings of potentiometers and encoders, relatively new technology has taken center stage: the MaxRotor.

As shown in the assembly diagram in Figure 8, the MaxRotor consists of a sandwich of mechanical parts on either side of a rigid or flexible circuit layer.

On the front side, a shaft, cover, and magnets are used with an optional detent ring to capture rotary motion from the user. As the magnets move across the top of the circuit layer, they pull with them a group of conductive metal balls that comprise the electrical armature on the backside of the circuit layer.

MaxRotor assembly.

The result of this unique assembly is a highly configurable, highly reliable rotary control that can offer the industry's thinnest overall depth.

From the top surface of the rotor to the bottom, the face is a mere 5.48 mm, all within a footprint of 25 mm x 25 mm.

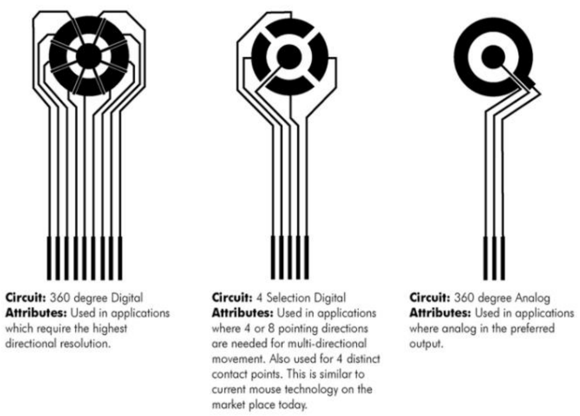
After extensive testing to several hundred-thousand rotations, the MaxRotor is rated at 100,000 rotations, almost double the reliability of traditional encoders and potentiometers.

The extended life of the MaxRotor is actually provided by the use of a state-of-the-art gold-plated chrome steel ball contact system. The gold-plated chrome steel balls free-roll along the surface of the circuit contacts, which greatly minimize wear on the circuit, and there is no heat build-up.

The rotor comparison in the figure below shows the extreme thickness difference of a variety of mechanical rotors versus the minimal overall height of the MaxRotor, depicted on the far right in Figure 9.

MaxRotor panel depth compared to the competition.

The circuit layer can be built into an off-the-shelf MaxRotor, or it can be fully customized in the end application as part of a larger PCB or Flex circuit. A few examples are shown in Figure 10.

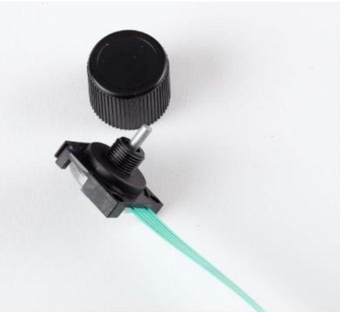


Examples of MaxRotor circuit options.

For the aforementioned LCD contrast control circuit, a simple analog circuit (far right) can be used to provide the exact same functionality as a potentiometer.

The MaxRotor itself can be customized on the circuit layer and the mechanical layer to include a variety of features ranging from push buttons and quadrature output to rotational stops and tactile detents.

In the case of an LCD contrast nob, a very simple design can be realized by creating a dedicated circuit layer and constructing a "stand-alone" MaxRotor as shown in Figure 11.



MaxRotor implemented as a standalone device.

This standalone configuration allows the MaxRotor to be easily installed alongside the keypad without integrating it into the same circuit board.

Figure 12, down below depicts the final implementation of the contrast knob and is a testament to the simplicity and capability of the MaxRotor.

MaxRotor contrasts control implementation.

Utilizing a MaxRotor as a Rotary Solution

At first glance, the proposed user interface design might have appeared to be constrained by the complexity of a keypad or LCD, when in fact, the basic function of rotary contrast control introduces the toughest mechanical challenges.

By using a few off-the-shelf components and a highly configurable MaxRotor, the interface can in fact be realized in a thickness less than 6 mm with minimal design complexity and high reliability.

In general, the MaxRotor provides engineering solutions to challenges and limitations that have plagued companies in their efforts to provide highly reliable rotary controls. Some examples of these solutions include:

- Extended product life through the use of engineering plastics for the molded components, high-quality metal components, and the use of a state-of-the-art gold plated chrome steel ball contact system.
- Thin panel integrated design inherently eliminates the need for a complex wire harness or the associated electrical circuitry and power consumption of mechanical rotors.
- The engineering design focused on providing a rotor with simple integration with other technologies, and successfully minimized the penetrating overall thickness of the rotor package.

As user interface panels continue to advance in their shape and complexity, the MaxRotor can be the next staple in every designer's toolbox.

IOT NETWORKING PROTOCOLS

Manisha M *Renugadevi N*

Introduction

Networking technologies enable IoT devices to communicate with other devices, applications, and services running in the cloud. The internet relies on standardized protocols to ensure communication between heterogeneous devices is secure and reliable. Standard protocols specify rules and formats that devices use to establish and manage networks and transmit data across those networks.

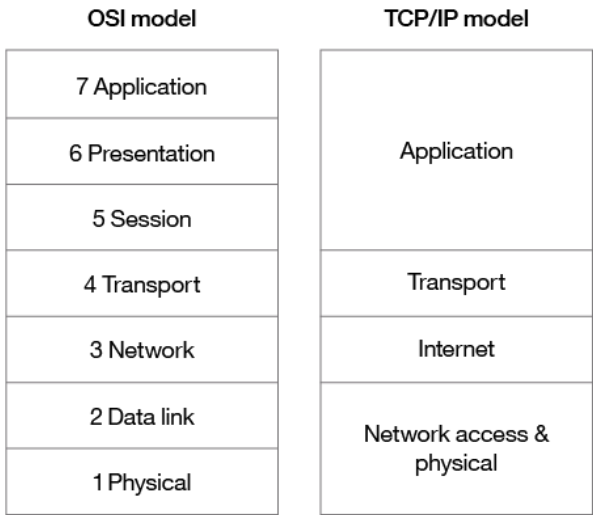
Networks are built as a "stack" of technologies. A technology such as Bluetooth LE is at the bottom of the stack. While others such as such as IPv6 technologies (which is responsible for the logical device addressing and routing of network traffic) are further up the stack. Technologies at the top of the stack are used by the applications that are running on top of those layers, such as message queuing technologies.

This article describes widely adopted technologies and standards for IoT networking. It also provides guidance for choosing one network protocol over another. It then discusses key considerations and challenges related to networking within IoT: range, bandwidth, power usage, intermittent connectivity, interoperability, and security.

Networking standards and technologies

The Open Systems Interconnection (OSI) model is an ISO-standard abstract model is a stack of seven protocol layers. From the top down, they are: application, presentation, session, transport, network, data link and physical. TCP/IP, or the Internet Protocol suite, underpins the internet, and it provides a simplified concrete implementation of these layers in the OSI model.

OSI and TCP/IP networking models



The TCP/IP model includes only four layers, merging some of the OSI model layers:

- **Network Access & Physical Layer** This TCP/IP Layer subsumes both OSI layers 1 and 2. The physical (PHY) layer (Layer 1 of OSI) governs how each device is physically connected to the network with hardware, for example with an optic cable, wires, or radio in the case of wireless network like wifi IEEE 802.11 a/b/g/n). At the link layer (Layer 2 of OSI), devices are identified by a MAC address, and protocols at this level are concerned with physical addressing, such as how switches deliver frames to devices on the network.

- **Internet Layer**

  This layer maps to the OSI Layer 3 (network layer). OSI Layer 3 relates to logical addressing. Protocols at this layer define how routers deliver packets of data between source and destination hosts identified by IP addresses. IPv6 is commonly adopted for IoT device addressing.

- **Transport Layer**

  The transport layer (Layer 4 in OSI) focuses on end-to-end communication and provides features such as reliability, congestion avoidance, and guaranteeing that packets will be delivered in the same order that they were sent. UDP (User Datagram protocol) is often adopted for IoT transport for performance reasons.

- **Application Layer**

  The application layer (Layers 5, 6, and 7 in OSI) covers application-level messaging. HTTP/S is an example of an application layer protocol that is widely adopted across the internet.

Although the TCP/IP and OSI models provide you with useful abstractions for discussing networking protocols and specific technologies that implement each protocol, some protocols don't fit neatly into these layered models and are impractical. For example, the Transport Layer Security (TLS) protocol that implements encryption to ensure privacy and data integrity of network traffic can be considered to operate across OSI layers 4, 5, and 6.

IoT networking protocols

Some of the networking protocols that are widely adopted within IoT and where they fit within the TCP/IP layers are shown in Figure 2.

IoT network protocols mapped to the TCP/IP model

TCP/IP model	IoT protocols
Application	HTTPS, XMPP, CoAP, MQTT, AMQP
Transport	UDP, TCP
Internet	IPv6, 6LoWPAN, RPL
Network access & physical	IEEE 802.15.4 Wifi (802.11 a/b/g/n) Ethernet (802.3) GSM, CDMA, LTE

Many emerging and competing networking technologies are being adopted within the IoT space. Multiple technologies from different vendors, target different vertical markets – home automation, healthcare, or industrial IoT – and provide alternative implementations of the same standard protocols. For example, IEEE 802.15.4 describes the operation of low-rate wireless personal area networks (LR-WPANs) and is implemented by several competing technologies including ZigBee, Z-Wave, EnOcean, SNAP, and 6LoWPAN.

Technologies used for internet connectivity, such as Ethernet, can be applied within the IoT. As you look further down the stack toward physical transmission technologies, you face more challenges that are specific to IoT devices and IoT contexts.

The structure of a network is known as its topology. The most common network topologies that are adopted within IoT are star and mesh topologies. In a star topology, each IoT device is directly connected to a central hub (gateway) that communicates with data from the connected devices upstream. In mesh topologies, devices connect to other devices within range. Nodes within the network can act as simple sensor nodes. Sensor nodes route traffic as can gateway nodes. Mesh networks are more complex than networks with star topologies. They are less prone to failure as they do not rely on a single central gateway.

Network access and physical layer IoT network technologies

IoT network technologies to be aware of toward the bottom of the protocol stack include cellular, wifi, and Ethernet, as well as more specialized solutions such as LPWAN, Bluetooth Low Energy (BLE), ZigBee, NFC, and RFID.

NB-IoT is becoming the standard for LPWAN networks, according to Gartner. This IoT for All article tells more about NB-IoT.

The following are network technologies with brief descriptions of each:

LPWAN

(Low Power Wide Area Network) is a category of technologies designed for low-power, long-range wireless communication. They are ideal for large-scale deployments of low-power IoT devices such as wireless sensors. LPWAN technologies include LoRa (LongRange physical layer protocol), Haystack, SigFox, LTE-M, and NB-IoT (Narrow-Band IoT).

Cellular

The LPWAN NB-IoT and LTE-M standards address low-power, low-cost IoT communication options using existing cellular networks. NB-IoT is the newest of these standards and is focused on long-range communication between large numbers of primarily indoor devices. LTE-M and NB-IoT were developed specifically for IoT, however existing cellular technologies are also frequently adopted for long-range wireless communication. While this has included 2G (GSM) in legacy devices (and currently being phased out), CDMA (also being retired or phased out), it also includes 3G, which is rapidly being phased out with several network providers retiring all 3G devices. 4G is still active and will be until 5G becomes fully available and implemented.

Bluetooth Low Energy (BLE)

BLE is a low-power version of the popular Bluetooth 2.4 GHz wireless communication protocol. It is designed for short-range (no more than 100 meters) communication, typically in a star configuration, with a single primary device that controls several secondary devices. Bluetooth operates across both layers 1 (PHY) and 2 (MAC) of the OSI model. BLE is best suited to devices that transmit low volumes of data in bursts. Devices are designed to sleep and save power when they are not transmitting data. Personal IoT devices such as wearable health and fitness trackers, often use BLE.

ZigBee

ZigBee operates on 2.4GHz wireless communication spectrum. It has a longer range than BLE by up to 100 meters. It also has a slightly lower data rate (250 kbps maximum compared to 270 kbps for BLE) than BLE. ZigBee is a mesh network protocol. Unlike BLE, not all devices can sleep between bursts. Much depends on their position in the mesh and whether they need to act as routers or controllers within the mesh. ZigBee was designed for building and home automation applications. Another closely related technology to ZigBee is Z-Wave, which is also based on IEEE 802.15.4. Z-Wave was designed for home automation.

NFC

The near field communication (NFC) protocol is used for very small range communication (up to 4 cm), such as holding an NFC card or tag next to a reader. NFC is often used for payment systems, but also useful for check-in systems and smart labels in asset tracking.

RFID

RFID stands for Radio Frequency Identification. RFID tags store identifiers and data. The tags are attached to devices and read by an RFID reader. The typical range of RFID is less than a meter. RFID tags can be active, passive, or assisted passive. Passive tags are ideal for devices without batteries, as the ID is passively read by the reader. Active tags periodically broadcast their ID, while assisted passive tags become active when RFID reader is present. **Dash7** is a communication protocol that uses active RFID that is designed to be used within Industrial IoT applications for secure long-range communication. Similar to NFC, a typical use case for RFID is tracking inventory items within retail and industrial IoT applications.

Wi-Fi

Wi-Fi is standard wireless networking based on IEEE 802.11a/b/g/n specifications. 802.11n offers the highest data throughput, but at the cost of high-power consumption, so IoT devices might only use 802.11b or g for power conservation reasons. Although wifi is adopted within many prototype and current generation IoT devices, as longer-range and lower-power solutions become more widely available, it is likely that wifi will be superseded by lower-power alternatives.

Ethernet

Widely deployed for wired connectivity within local area networks, Ethernet implements the IEEE 802.3 standard. Not all IoT devices need to be stationery wireless. For example, sensor units installed within a building automation system can use wired networking technologies like Ethernet. Power line communication (PLC), an alternative hard-wired solution, uses existing electrical wiring instead of dedicated network cables.

The dawn of 5G networks

5G is the next generation of wireless networks. It builds existing 4G Long-Term Evolution (LTE) infrastructure. Notably, bandwidth is improved. But so is capacity, and reliability of wireless service.

5G is ideal for more data and communication requirements brought for the by the billions of connected devices that will make up the Internet of Things (IoT). It also aids the ultra-low latency requirement for real-time communications. It is an all-new data pipeline that serves as the plumbing for every signal, from every device that uses the Internet. It can handle dense data.

It is fast – about twenty times faster than 4G, enabling the user to download video, say, in just 17 seconds. It is a boost to our connected world in the age of IoT, and a discernible boost to what IoT can accomplish in the future.

The arrival and full implementation of 5G is still in early implementation; soon it will be old. Rest assured, it will make our world better, our lives better, and allow the fruits of technology to shine with a tad more luster than ever before as data moves in greater volumes, quicker than ever.

Internet layer IoT network technologies

Internet layer technologies (OSI Layer 3) identify and route packets of data. Technologies commonly adopted for IoT are related to this layer, and include IPv6, 6LoWPAN, and RPL.

IPv6

At the Internet layer, devices are identified by IP addresses. IPv6 is typically used for IoT applications over legacy IPv4 addressing. IPv4 is limited to 32-bit addresses, which only provide around 4.3 billion addresses in total, which is less than the current number of IoT devices that are connected, while IPv6 uses 128 bits, and so provides 2^{128} addresses (around 3.4×10^{38} or 340 billion billion billion billion) addresses. In practice, not all IoT devices need public addresses. Of the tens of billions of devices expected to connect via the IoT over the next few years, many will be deployed in private networks that use private address ranges and only communicate out to other devices or services on external networks by using gateways.

6LoWPAN

The IPv6 Low Power Wireless Personal Area Network (6LoWPAN) standard allows IPv6 to be used over 802.15.4 wireless networks. 6LoWPAN is often used for wireless sensor networks, and the Thread protocol for home automation devices also runs over 6LoWPAN.

RPL

The Internet Layer also covers routing. IPv6 Routing Protocol for Low-Power and Lossy Networks (RPL) is designed for routing IPv6 traffic over low-power networks like those networks implemented over 6LoWPAN. RPL (pronounced "ripple") is designed for routing packets within constrained networks such as wireless sensor networks, where not all devices are reachable at all times and there are high or unpredictable amounts of packet loss. RPL can compute the optimal path by building up a graph of the nodes in the network based on dynamic metrics and constraints like minimizing energy consumption or latency.

Application layer IoT network technologies

HTTP and HTTPS are ubiquitous across internet applications, which is true also within IoT, with RESTful HTTP and HTTPS interfaces widely deployed. CoAP (Constrained Application Protocol) is like a lightweight HTTP that is often used in combination with 6LoWPAN over UDP. Messaging protocols like MQTT, AMQP, and XMPP are also frequently used within IoT applications:

MQTT

Message Queue Telemetry Transport (MQTT) is a publish/subscribe-based messaging protocol that was designed for use in low bandwidth situations, particularly for sensors and mobile devices on unreliable networks.

AMQP

Advanced Message Queuing Protocol (AMQP) is an open standard messaging protocol that is used for message-oriented middleware. Most notably, AMQP is implemented by RabbitMQ.

XMPP

The Extensible Messaging and Presence Protocol (XMPP) was originally designed for real-time human-to-human communication including instant messaging. This protocol has been adapted for machine-to-machine (M2M) communication to implement lightweight middleware and for routing XML data. XMPP is primarily used with smart appliances.

Your choice of technologies at this layer will depend on the specific application requirements of your IoT project. For example, for a budget home automation system that involves several sensors, MQTT would be a good choice as it is great for implementing messaging on devices without much storage or processing power because the protocol is simple and lightweight to implement.

IoT networking considerations and challenges

When you consider which networking technologies to adopt within your IoT application, be mindful of the following constraints:

- Range
- Bandwidth
- Power usage
- Intermittent connectivity
- Interoperability
- Security
- Range

Networks can be described in terms of the distances over which data is typically transmitted by the IoT devices attached to the network:

PAN (Personal Area Network)

PAN is short-range, where distances can be measured in meters, such as a wearable fitness tracker device that communicates with an app on a cell phone over BLE.

LAN (Local Area Network)

LAN is short- to medium-range, where distances can be up to hundreds of meters, such as home automation or sensors that are installed within a factory production line that communicate over wifi with a gateway device that is installed within the same building.

MAN (Metropolitan Area Network)

MAN is long-range (city wide), where distances are measured up to a few kilometers, such as smart parking sensors installed throughout a city that are connected in a mesh network topology.

WAN (Wide Area Network)

WAN is long-range, where distances can be measured in kilometers, such as agricultural sensors that are installed across a large farm or ranch that are used to monitor micro-climate environmental conditions across the property.

Consider the following factors in shaping a secure and safe IoT network:

Authentication

Adopt secure protocols to support authentication for devices, gateways, users, services, and applications. Consider using adopting the X.509 standard for device authentication.

Encryption

If you are using wifi, use Wireless Protected Access 2 (WPA2) for wireless network encryption. You may also adopt a Private Pre-Shared Key (PPSK) approach. To ensure privacy and data integrity for communication between applications, be sure to adopt TLS or Datagram Transport-Layer Security (DTLS), which is based on TLS, but adapted for unreliable connections that run over UDP. TLS encrypts application data and ensures its integrity.

Port protection

Port protection ensures that only the ports required for communication with the gateway or upstream applications or services remain open to external connections. All other ports should be disabled or protected by firewalls. Device ports might be exposed when exploiting Universal Plug and Play (UPnP) vulnerabilities. Thus, UPnP should be disabled on the router.

Conclusion

Proper selection of IoT networking technologies requires compromise. Selected networking technologies will impact the design of IoT devices. The considerations suggested in this article depend on many factors. For example, network range, data rate, and power consumption are all directly related. If you increase the network range or rate and volume of data that is transmitted, your IoT devices will certainly require additional power to transmit the data under those conditions.

For basic home automation, the power consideration criterion is likely of low importance; the device would most likely be powered directly from a wall socket. Bandwidth limitations and drop-outs in connectivity are higher priorities. Wifi provides reasonable bandwidth and expedites the project by using commodity hardware. However, wifi is not optimized for low-power devices, making it an unwise choice for a battery-powered device.

This article provides an overview of some of the most common networking protocols and technologies for IoT. It is most important to consider your requirements in light of these IoT networking challenges to find the technologies that will be the best fit for your IoT application.

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Conclusion

The concept of Microwave Power transmission (MPT) and Wireless Power Transmission system is presented. The technological developments in Wireless Power Transmission (WPT), the advantages, disadvantages, biological impacts and applications of WPT are also discussed. This concept offers greater possibilities for transmitting power with negligible losses and ease of transmission than any invention or discovery heretofore made.

Program Outcomes (POs)

PO1	**Engineering Knowledge:** Apply the knowledge of mathematics, science, and engineering fundamentals to solve the complex electrical engineering problems.
PO2	**Problem Analysis:** Identify, formulate, review research literature, and analyze complex Electrical and Electronics Engineering problems enabling attainment of conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions:** Design solutions, components or process for complex Electrical Engineering problems to meet the specified needs considering public health, safety and environmental considerations.
PO4	**Conduct Investigations of complex problems:** Exercise research knowledge and technical methodology for design, analysis and interpretation of data to converge to a suitable solution.
PO5	**Modern Tool Usage**: Use modern engineering tools, softwares and equipments to predict, analyze and model engineering problems.
PO6	**The Engineer & Society:** Apply reasoning skills to assess societal, health, safety, legal and cultural issues relevant to the professional engineering practice and take consequent responsibilities in the society
PO7	**Environment and Sustainability:** Realize the impact of the professional engineering solutions and demonstrate the knowledge for sustainable development in environmental context
PO8	**Ethics:** Apply and realize the professional ethics and responsibilities in Electrical engineering practice.
PO9	**Individual and Team Work:** Exhibit Individuality, Leadership and Team spirit in multidisciplinary settings.
PO10	**Communication:** Communicate, comprehend, write reports, design documentation and presentation effectively on complex engineering activities
PO11	**Project Management & Finance:** Demonstrate the Electrical engineering and management principles adhering to financial strategies to manage projects as a member or leader in a team
PO12	**Life Long Learning:** Inculcate independent and life-long learning in the broadest context of technological change.

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PSO 1: Electrical drives and control: Graduates will Analyze, design and provide Engineering solutions in the field of Power Electronics and Drives

PSO 2: Embedded system: Graduates will Simulate, experiment and solve complex problems in Embedded System.

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BEES Magazine

August 2020